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# THE SCHOOL REVIEW

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## THE STUDY OF EXPERIMENTAL PEDAGOGY IN GERMANY

### FOURTH ARTICLE

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We have already learned of the daily fluctuations in psychical energy and have drawn conclusions from the fact that one of its maxima falls in the morning and another in the afternoon. The old way of dividing the time of instruction between the two parts of the day seemed to us more advantageous than the newer usage which imposes on the pupil five hours of such instruction during the morning. The grain should be cut when it is ripe. The school ought to utilize the psychical energy of the pupil at the right time, that is, in the afternoon also when it reaches its second maximum, as well as in the morning. No less ought the psychical energy be spared at the right time. For this reason we recommended instruction periods of 45 minutes with 15 minutes' intermission. In like manner we demanded a shortening or a transformation of the home-work. As in all these demands the hygienic point of view was uppermost, so our present article serves primarily the didactic. From the investigations as to the change in psychical energy during the day, there arises an especial problem for the teacher.

It is clear, of course, that, in determining the sequence of subjects in which a pupil is instructed during the day, proper regard must be paid to the course of psychical energy. The

experienced teacher will assign his pupils easier subjects when their psychical energy is at an ebb. He will reserve the presentation of more difficult subjects until it is, so to speak, high-tide, i. e., when the energy is at the high points of the day. Inasmuch, therefore, as, on the average, the psychical energy is comparatively low at 8 o'clock, rises about 9 o'clock and reaches its maximum toward 11:00, the best arrangement of three subjects of unequal difficulty would be to set the easiest for 8:00, the next in difficulty at 9:00 and the hardest last. By the hardest would be meant the subject that consumed the most psychical energy of the pupils, i. e., fatigued them the most.

An objection might be raised against this arrangement, namely, that not the relative state of psychical energy should be decisive in the assignment of subjects, but rather the absolute fatigue of the pupils should be taken into account. The latter continues to increase from hour to hour. At the end of the fourth hour the pupils are in such a fatigue-narcosis that their mental effectiveness, certainly the value of that which they would have accomplished under such circumstances, is reduced to zero. The hardest subject, therefore, must always be placed at the beginning of the school-day in order to get the full value of the fresh energy of the pupils. The remaining subjects would have to follow according to the diminishing degree of effort which they would demand.

The principle of arrangement is directly opposed to the one previously mentioned. In the case of the new proposal it is assumed, first, that the effects produced on the pupils by successive hours of instruction are cumulative and, second, that work performed during fatigue is without educational value. The latter view is in accordance with the general opinion and is correct. Kraepelin and his students have been able to confirm it by countless interesting laboratory experiments. Kraepelin worked with students and assistants by having the subjects of his experiments add numbers of one figure which were arranged under one another in specially prepared blanks. When the sum passed a hundred, the hundred was dropped and the addition was continued with the remaining units. Every five minutes

a signal was given. Then the calculator drew a line under the number last added. It was thus seen how many figures were added in every five minutes by each person. Kraepelin often had these experiments continued for hours. He thus created for himself a means of detecting, through the lessening or increase of the number added, the effects of fatigue, as well as of the inserted periods of recreation. He was concerned exclusively with the number of figures added in the unit of time. The quality of the result in this sort of a test was disregarded. The conclusions gained through this simple procedure are extremely instructive. Kraepelin has given the most comprehensive account of the experiments in his article, "*Die Arbeitskurve*."<sup>1</sup> The abscissae mark the periods of time over which the experiments extend: the ordinates indicate how many numbers were added within each period. The curve in question starts with higher ordinate-values only to fall immediately. Such sudden mountings followed by a speedy drop recur throughout the curve. In this we recognized the effort of the will to collect oneself, the impulse which can be maintained on an even level only a short time and just in such conditions of fatigue is often repeated. After that initial drop due to the abatement in the will-tension, the curve mounts gradually again until far above the original height. In this fact the influence of practice, which is the most powerful counter-influence against the effects of fatigue, is disclosed. While the latter, as soon as they set in, lower the level of achievement, i. e., lessen the number of figures added, practice has the tendency constantly to heighten this level. Furthermore, this takes place only up to a certain limit. For the higher the level already reached by practice, the less effect does the continuation of the practice have in the way of raising the level further. "With rising level of practice," we may say, "the capacity for practice gradually decreases."<sup>2</sup>

We have heard that the work-curve (*Arbeitskurve*) at first rises under the influence of practice, but if one continues the adding without stopping, the curve begins to sink, at a slight

<sup>1</sup> In *Wundt's Philosophische Studien*, Vol. XIX, 1902.

<sup>2</sup> Kraepelin, *Psychologische Arbeiten*, Vol. I, pp. 652, 674.

rate at the start, but later more and more abruptly. This is the effect of fatigue. Were it not for this, the height of the ordinates would have to increase the longer one worked, because of the effect of practice. This, however, does not take place, but the work-curve falls if one continues to work; it not only falls, but it falls more and more abruptly. The conclusion is obvious: *The practice-value of a work becomes smaller the longer the fatiguing activity continues.* Fatigue diminishes more and more the return to be got from practice.<sup>3</sup> Here we have the experimental proof of the sentence with which we began, that work performed during fatigue is without educational value.

It is worth while to dwell a little longer on the experiments of Kraepelin and his pupils. We want to be told what form the curves assume when the work of adding is resumed, say after a rest of 24 hours. From the beginning the curves are higher than before and, the time-period remaining the same, they remain in all their stages raised above the corresponding level of the preceding curves. Herein is revealed that psycho-physical relationship upon which all educability (*Bildsamkeit*), to use Herbart's word, rests. That is, practice leaves lasting traces in the life of the mind, while fatigue is always completely overcome by sleep and nourishment. Consequently the effects of practice increase from experiment to experiment. Fatigue on the contrary is produced anew each time by work. The work-achievement begins each time therefore on a higher level and maintains itself there until the gradually developing fatigue lowers it again.<sup>4</sup> The new curves are distinguished from the earlier not only by their higher position but by their form. The second, third, fourth, etc., curves become more and more even. We already know that they must rise more evenly. This is the expression of the practice already acquired, which admits of little gain through further practice. But the curves fall more evenly and more gradually, i. e., fatigue also does not operate so powerfully as the experiments continue. We gain therefore the noteworthy

<sup>3</sup> According to the experiments of Rivers; see Kraepelin, *op. cit.*, Vol. I, p. 652.

<sup>4</sup> Kraepelin, *op. cit.*

result that, "with increasing practice not only the capacity for practice but also susceptibility to fatigue diminishes."

Finally, from the above-named experiments not much light is thrown on the effect of the interval of rest. All the factors which have developed during the preceding activity are subject to the changing effect of the intervals, but they are not all thus subject during the same period of time, nor in the same way. Our psycho-physical organism assumes for every activity a certain tendency to persist. The psychical rollers and wheels are ready, even after a cessation of the activity, at once to go on humming again with the same momentum. If the interval is short, the impulsion outlasts the interruption of the work, or at any rate only a part of the impulse is lost. Amberg<sup>5</sup> was able to show that a fifteen-minute pause after a half-hour's adding left no trace of this impulse. It was otherwise in case of a pause of only five minutes; from the unexpectedly large number added on resumption of the work, it was seen how favorably the impulse continued to operate in lightening the work. Whoever wishes to interrupt but not discontinue a task must avoid too long pauses, provided fatigue is not too great. The little fatigue is overcome by a short pause and the inner disposition of the organism is maintained. If the latter is allowed to disappear through a longer interval, then revenge comes through the relatively low values of the newly begun work.

We have just noted that the traces of fatigue are very quickly obliterated by a short interval of rest. This is true of fatigue, resulting from experiments, or in general of the temporary fatigue due to work, which we may call "occasional" fatigue. The day's fatigue, of course, is not stayed by intervals of rest, but takes its indicated course, which is determined by the curve of psychical energy. This work-fatigue has its origin in the fact that the blood-paths are filled with the products of decomposition from the working nerves. Thereby the activity of the latter is more and more paralyzed. But the products of assimilation are quickly separated from the blood as soon as the intense

<sup>5</sup> *Ibid.*; also Kraepelin, "Ermüdungsmessungen," *Archiv für Physiologie*, Vol. I.

activity ceases. Fatigue of this sort is not dangerous but only, as it were, a warning-signal of the organism to avoid premature exhaustion of one's powers. Such exhaustion or permanent fatigue would result only if the fatigue-paralysis is not heeded but one continues to work in the same way and with the same intensity. Meumann reports that the blood-pressure of many of his subjects after two or three hours' work fell so much that one might readily call it heart-failure. Here we have the type of injurious over-exertion.

It is evident that with greater degrees of fatigue, the intervals of rest which removes its traces must be longer. After a half-hour's learning of "non-sense syllables," for instance, the pauses of five minutes which were so advantageous after a half-hour's adding, would be too short. The fifteen-minutes interval proves better (Amberg). To be sure, the condition of stimulation, with its tendency to carry over the level of achievement of the preceding activity to the new, disappears. But in this case, there disappear now for the first time the traces of fatigue-paralysis which had counterbalanced not only the supporting influences of the stimulation, but also the increasing effects of practice.

Fortunately the gain resulting from practice (of weeks, yes, months) can never fully vanish. The leveling power of the intervals can weaken it more or less. There occurs at first a speedy, later a gradual loss of practice, but a residue of practice always persists. The energy vanishes quickly after the cessation of activity, fatigue more slowly; on the contrary, the results of practice and especially of habit remain under certain conditions weeks or months.

These circumstances explain the change in the form of the work-curve after the inserted intervals. We have already studied this form on the assumption of longer interruptions which would not pass as "intermissions" in the accepted sense. Its appearance after intervals of rest depends on the length of the latter. Before the interval, the fatigue-effects had stifled more and more the practice-effects. Since under the restoring influence of the interval of rest the fatigue-paralysis diminishes, the level of achievement begins to rise and the ordinates marking the quantity of

work, which had gone far down, increase again. If the interval was long enough greatly to reduce the fatigue-products and not too long so as to permit a considerable loss of practice, the ordinates on account of the unimpaired practice-gain mount higher than during the entire previous activity, the higher, the more favorable the interval. It follows that there must be a most favorable interval. It is such as permits the excess of the practice-result over the fatigue effect to reach its maximum. Up to this point, the capacity for work is impaired by the last traces of fatigue. According to Kraepelin's experience the length of the most favorable interval is affected in no way, or at most but slightly, by the duration of the preceding work. It does, however, vary for different persons within very wide limits, reaching from a quarter of an hour to more than an hour. There is no better test by which to determine one's liability to fatigue than to establish what is his most favorable interval. The above-described experiments deserve to be heeded by every schoolman, not only for theoretical reasons because they analyze in a masterly fashion the elements of work, but for practical reasons as well on account of the important conclusions as to the effects of intervals of rest. These observations give a clue also for the deciding of the question which we had left unsettled.

The question was whether the capacity of the pupils follows the curve of mental energy, i. e., increases until 11:00 and then abruptly falls, rising again in the afternoon, or whether the school-fatigue of the pupils becomes greater from hour to hour so that their capacity continually decreases in the successive hours of the day. Kraepelin misled by the frightful fatigue-results of hours of adding, was formerly inclined to the latter view.<sup>6</sup> But his more recent experiments concerning the restoring effect even of short intervals (of a minute) are opposed to the pessimism of this view. School-instruction affords an abundance of such brief pauses. Moreover as Gustav Richter, the director of the gymnasium in Jena, has emphasized,<sup>7</sup> it is quite a different matter if an experimenter busies himself for two or three hours

<sup>6</sup> Kraepelin, *Ueber geistige Arbeit*, 1894.

<sup>7</sup> G. Richter, *Unterricht und geistige Ermüdung*, 1895.



with a monotonous adding, than when a pupil lives through the various situations of instruction. If one lets drops of water fall for two hours on the same spot of the hand, there results an almost unbearable pain and diseased inflammation of the skin. If, however, one uses the hands for the same length of time in all sorts of occupation, alternating with one another, the fatigue is hardly noticed.

After all, the saying that recreation lies in change alone, is not so certain as the practical schoolmen are fond of believing. The nerve specialists dispute it. Change of work, says Kraepelin, dispels only the feeling of ennui in which one feels tired of a thing. This subjective feeling of fatigue has nothing to do with real fatigue which springs from the consumption of physical energy. True (objective) fatigue, i. e., deterioration of the blood by decayed material in case of a high degree of exhaustion of the strength-supply (vitality), always involves a lowering of achievement. In a condition of ennui, i. e. of a non-active, or of an unconcentrated attention, the power of achievement can even increase, according to the communications of Rivers. It is a question whether true fatigue yields to change as it is certain that a change in activity removes the feeling of ennui. Just because fatigue is a general condition of the nervous system, it must, according to Kraepelin, be increased by every continuation of work, no matter whether it follows in the same or in a new direction.

It is possible, of course, that in school circles too much reliance has been placed on the recreative effects of change, mere change: that the short pauses in instruction, the intervals and other factors which have yet to be emphasized serve better to obviate exhaustion than change. But the argument which we have just listened to does not hold. One forgets the old saying, "He who proves too much proves nothing." The argument is intended to prove that recreation does not consist in change, but it actually proves that there can be no recreation at all. For activity in the energetic sense, i. e., activity of the nervous system, is a mere being awake, a conscious activity, as such. So viewed,

every pause is nothing but a change in activity. A "recreative" effect of pauses would be unthinkable.

In fact, we have here a dark corner in our fatigue-psychology. Its advocate asserts that fatigue advances continuously and uninterruptedly even through the mere being awake. How, then, can the capacity for work ever rise again when once, as the result of any activity, it has fallen? How can its further decline be averted for even a short time? And yet we know most certainly and the physiologists prove it in countless experiments, that after higher degrees of fatigue, every long pause produces a considerable rise in the much-lowered capacity for work, which counterbalances the loss of practice and the diminution of momentum, so that in spite of the interruption, more is accomplished in the entire time than if the work went on continuously.

Here facts stand over against assertions. The physiologists teach us that fatigue constantly increases. A series of facts teaches us that the lowered capacity for work can be raised. Another set of facts teaches us that the curve of psychical energy describes during the day the form of a wave. At this point a warning against a certain dogmatism of fatigue-physiology will not be without its justification.

Let us consider further the pertinent facts. From Kraepelin's experiments it appears not only that practice counteracts *existing* fatigue, but also that with every increased degree of practice, the susceptibility to fatigue decreases. This result is gratifying from a pedagogical point of view. To it corresponds the fact that the value of the pupils' achievement, in spite of incipient fatigue, does not necessarily decrease during the same hour of instruction, although it may do so. The bad thing about it is that under the counteracting effects of fatigue the capacity for practice is also reduced, so that instruction fails of its object to promote mental progress.

The second fact is gratifying from a hygienic and pedagogical point of view. For it precludes to a certain degree the development within a period of instruction of a further condition of fatigue precisely through the advance in practice. That is to say, the *activity* into which the pupil is brought through the drill

of instruction, has the effect of staying fatigue, just as the small natural intervals in instruction have the effect of removing fatigue. This consideration also renders the assumption that fatigue in school must constantly increase, to say the least, not quite self-evident.

Kraepelin has advanced the same point of view in fine words, which deserve to be pondered. He writes, "It is certain that practice lessens the liability to fatigue. The only proper means, therefore, of preventing the appearance of fatigue-phenomena is just the work which itself produces fatigue. If, then, at the first show of signs of fatigue the school should discontinue the work, it is to be feared that it would also sacrifice the practice-effect of the work. Instead, therefore, of reducing the liability to fatigue, the instruction would lead to a weakening. The liability to fatigue would remain permanently in its original status and the growing multitude of weaklings would anxiously vibrate between short periods of work and long periods of rest."<sup>8</sup>

We have further an indirect proof that with intelligent instruction the pupils can remain fresh and capable of work even in the third and fourth periods. Because fatigue lowers the practice-value of what is accomplished, and increasing practice all the more so, the pupils would of necessity make less progress in the third and fourth hours in proportion as their fatigue had increased in those hours. But it has been observed that the subjects taught in the third and fourth hours have shown such failure to make progress.

Finally, at the close of the recitation periods, simple and homogeneous tests such as adding of digits, copying of texts, dictation, etc., were set for the pupils in order to observe from the results of their work the condition of fatigue. We shall have presently to consider more closely such fatigue-measurements. They are not so simple nor so unambiguous as has been believed. All these subordinate factors, practice, impetus, stimulus, which Kraepelin has so carefully described and which counteract or thwart the influences of fatigue, play a part in

<sup>8</sup> *Zur Ueberbildungsfrage*, pp. 15 f.

these tests. Other entirely unforeseen difficulties also meet us here.

Let one example serve for many. It is certain that the hour from one to two brings the minimum of psychical energy. This relatively low level persists if dinner, which in Germany generally ends about this time, should have in the meantime removed the fatigue of the children; nevertheless, it happens that many pupils, in order to have leisure for playing later on, undertake their home work at this unsuitable hour. One would expect that the work produced at this time would be, in general, of little value. It was with this expectation that Dr. Friedrich Schmidt of Würzburg<sup>9</sup> compared the same home lessons which were done by school children in the hours named (1:00 to 2:00) with the work of other children who studied from 5:00 to 6:00, 6:00 to 7:00, 7:00 to 8:00, or 8:00 to 9:00. He found to his surprise that the tasks completed from 1:00 to 2:00 compared very favorably when they were of a more mechanical character, as for example, the copying of easy school material (narratives with a moral, or multiplication, or division with numbers of more than one figure. The hour from one to two showed itself to be injurious in the case of more intellectual work; for example, the writing of German compositions on such themes as, "How far is fire a benefactor of mankind?"

The above example teaches us that not every task is an equally good test of the fluctuation of psychical energy and, by analogy, of the phenomena of fatigue. The degrees of modification in the psychical energy escape detection in one set of exercises and only become apparent in others. For this reason we ought to regard the experiments to determine the fatigue of pupils through all sorts of test work with due caution.

It is surprising, to say the least, what Laser,<sup>10</sup> who, at the time, could have known nothing of the periodicity of psychical energy, has told us from the results of his experiments. He made a test of the increase of fatigue after the successive hours

<sup>9</sup> Friedrich Schmidt, "Experimentelle Untersuchungen über die Hausarbeiten des Schulkindes," *Archiv für die gesamte Psychologie*, Band III, 1904.

<sup>10</sup> Laser, "Ueber geistiger Ermüdung beim Schulunterricht."

of instruction by having the pupils do simple examples for ten minutes after each hour. The number of the computed digits, therefore the capacity for work, proved lowest in the first hour. The capacity for work increased up to the third or fourth hour, and decreased again in the fourth or fifth. As a result, we get not a curve of increasing fatigue reckoned from the first hour on, but such a course of the capacity for achievement as we could derive in advance from the day's curve of the psychical energy.

I mention further the result gained by G. Richter<sup>11</sup> who set for his pupils in the intermissions between lessons algebraic problems, for example,  $13a - 4b - (5c + 2a) - (5c + 2a) - (6a - 4b) - 2c = ?$ , or dictated to them the forms of the Greek conjugations—*δίδοται*, *δίδωται*, etc. His conclusion is that, on the whole, the pupils' capacity for work during the time of instruction maintains itself well. A lessening of the mental elasticity is observed only in the fifth hour and yet this was far from being a condition of exhaustion.

Ebbinghaus<sup>12</sup> has examined most carefully the question as to whether the pupils become more and more fatigued in the course of instruction. His results also refute the pessimistic view to which physicians here are readily inclined.

Ebbinghaus reckoned at the start with the possibility that the fatigue-tests, according to the kind of testwork, might show now one and now another result. On this account he used a threefold method during different school days at the beginning and end of the school periods. The first method consisted of a test of direct memory. He tested to what number of terms the pupils could repeat, offhand, rows of figures which the teacher was to read to them but once. In the second test Ebbinghaus had the pupils solve for ten minutes easy problems in addition and multiplication. In this case it was a question primarily of the firmness and quickness with which associations were made. The last test was directed toward the intelligence, or to speak more correctly, toward the supplementing power of imagination

<sup>11</sup> Cf. above, p. 639.

<sup>12</sup> Ebbinghaus discusses this in his *Zeitschrift für Physiologie und Psychologie der Sinnesorgane*, Bd. XIII, S. 401 ff.

possessed by those examined. Simple texts with omitted syllables or words were given to be filled out. The test as to direct memory furnished no result as to the question of fatigue. It was rather true that after the fourth or fifth hour the numbers remembered increased than that fatigue visibly decreased. In the case of the solution of the arithmetical problems the mistakes increased from the end of the first up to the fifth hour, but only to a small degree, 3 to 4 per cent. Also the combination-test in the case of pupils of the middle and upper classes brought to light no higher degrees of fatigue, but only such as on account of the counter-influence of practice remain without harm. The number of the syllables supplied increased from the first to the fourth hour without any noticeable increase in the per cent of mistakes. In the fifth hour a noticeable deterioration first showed itself. For this reason the younger pupils fared worse in the combination-test. In their case the result at the end of four periods of instruction was only two-thirds of that shown at the beginning of the day. The necessity of protecting the younger and therefore untrained pupils becomes apparent. Equally clear is it also that the psychical energy of the middle and higher years is adequate for a four-hour morning session. Here again we have a confirmation of what already might have been inferred from Kraepelin's observations. The factors of recreation and practice which a well-regulated instruction affords as well as the intermissions placed between the hours of instruction, effectively counteract for long periods of time the increase of fatigue.

Herewith we have to some extent solved the problem which we set for the present discussion, the problem of the recitation programme. In drafting such a programme one may assume that the pupils during four hours of instruction remain fresh enough for each subject. The subjects themselves must therefore be arranged in such a way that their order will correspond to the course of psychical energy. The harder subjects, therefore, belong in the hours of greater energy. Whether and to what extent indeed this principle of arrangement can be experimentally carried out we shall learn in our next article.